

GRANULAR FLAME-RETARDANT COMPOSITION

- [0001] The present invention relates to a granular flame-retardant composition, and also to a process for preparing this granular flame-retardant composition, and to the use of the composition.
- [0002] Organophosphorus compounds are used as flame retardants for plastics such as polyamides or polyesters.
- [0003] In the abovementioned application sectors, the processing of the organophosphorus flame-retardant component can be made more difficult by its low bulk density. Low bulk density makes infeed of the material into continuously operating machines more difficult, especially in the case of extruders used with plastics injection molding machines. The result can be non-uniform dispersion of the material in the polymer.
- [0004] DE 196 50 563 A1 describes pellets comprising a thermoplastic polymer, a graft polymer, a thermoplastic copolymer, and a flame retardant comprising iminophosphoranes.
- [0005] EP 1 081 190 A1 describes flame-retardant thermoplastic molding compositions comprising at least one of the following components: high-molecular-weight syndiotactic polymer based on vinylaromatic monomers and on polyphenylene ether, vinylaromatic amorphous polymer, and flame retardant.
- [0006] DE 41 39 625 A1 describes pellets composed of polyphenylene ether, vinylaromatic polymers, and an aromatic phosphite.
- [0007] EP 0 899 296 A2 describes polymer molding compositions comprising a synergistic flame retardant combination for thermoplastic polymers, these being composed of a salt of 1-hydroxydihydrophosphole oxides

with another component from the group of benzoguanamine, tris(hydroxyethyl) isocyanurate, allantoin, glycoluril, and also melamine cyanurate, melamine phosphate, dimelamine phosphate, and melamine pyrophosphate, and ammonium polyphosphate.

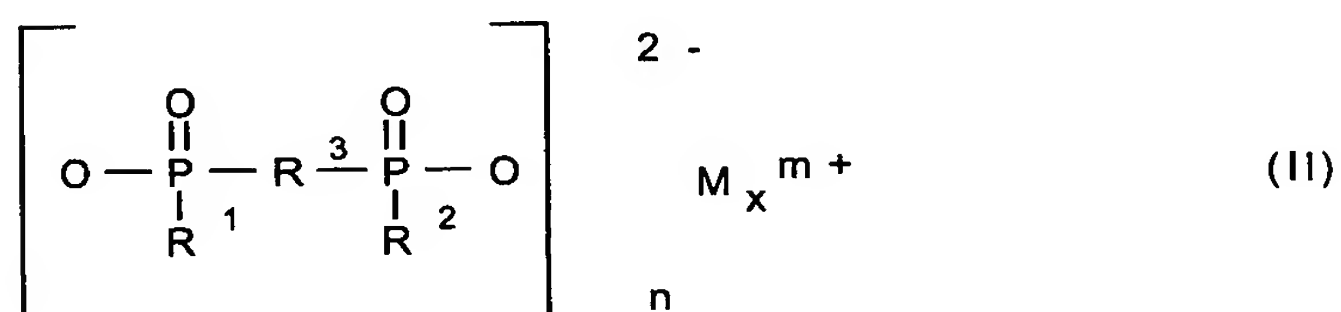
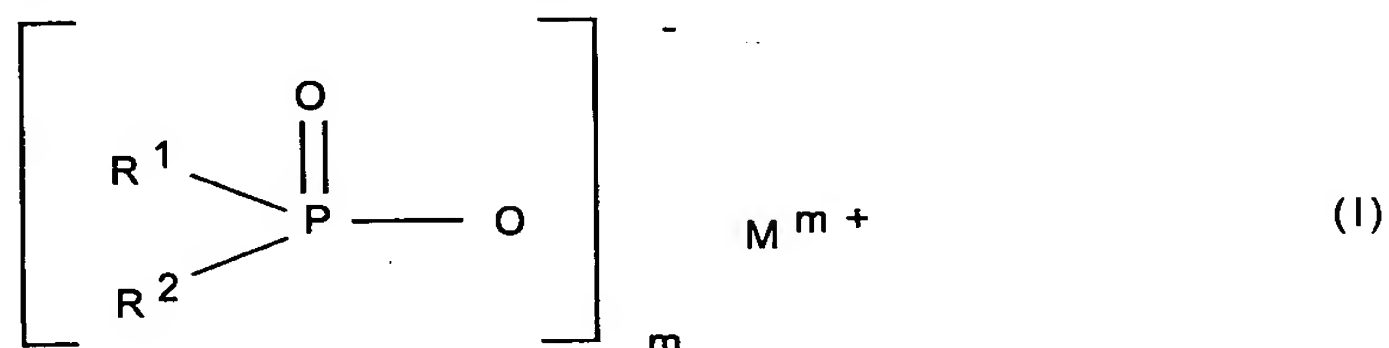
[0008] US 5,021,488 A1 and US 5,102,931 A1 describe thermoplastic, flame-retardant, non-dripping polyamide compositions whose preparation uses phosphinic esters of polyphenols, anti-dripping agents, polyfluoroethylene polymer, aramid, and/or zinc borate (hydrates), in a granular or pulverulent form.

[0009] US 5,191,000 A1 describes flame-retardant non-dripping polyalkylene terephthalate compositions whose preparation uses phosphorous esters and anti-dripping agents, in a granular or pulverulent form.

[00010] It was therefore an object to eliminate the disadvantages of the prior art and improve the processibility of flame-retardant compositions. The invention achieves the object by treating the organophosphorus flame-retardant component with a binder and granulating the material. Surprisingly, it has been found that the uniformity of dispersion of the OPF in the polymer is improved if the OPF is used in the form of melt granules. The particles have better dispersion and give more effective flame-retardant action. Other results of the better particle distribution are seen in the surface finish and surface quality, which are better and have improved esthetic properties. Better mechanical strength properties are another possible result.

[00011] The invention therefore provides a granular flame-retardant composition composed of an organophosphorus flame-retardant component, and at least one binder.

[00012] The organophosphorus flame-retardant component preferably comprises a phosphinic salt of the formula (I) and/or a diphosphinic salt of the formula (II) and/or polymers of these (component A),



where

R^1 and R^2 are identical or different and are C_1 - C_6 -alkyl, linear or branched, and/or aryl;

R^3 is C_1 - C_{10} -alkylene, linear or branched, C_6 - C_{10} -arylene, -alkylarylene, or -arylalkylene;

M is Mg, Ca, Al, Sb, Sn, Ge, Ti, Zn, Fe, Zr, Ce, Bi, Sr, Mn, Li, Na, K, and/or a protonated nitrogen base;

m is from 1 to 4;

n is from 1 to 4;

x is from 1 to 4.

M is preferably calcium, aluminum, or zinc.

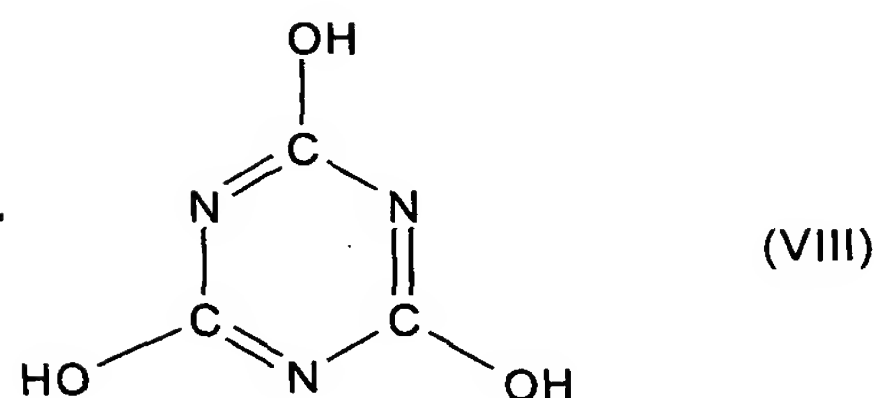
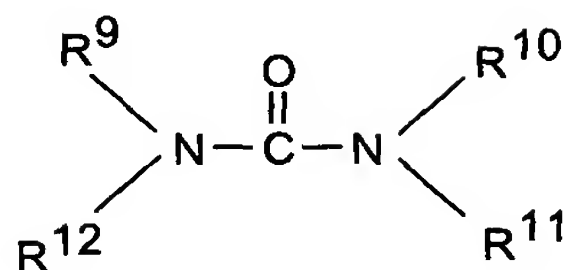
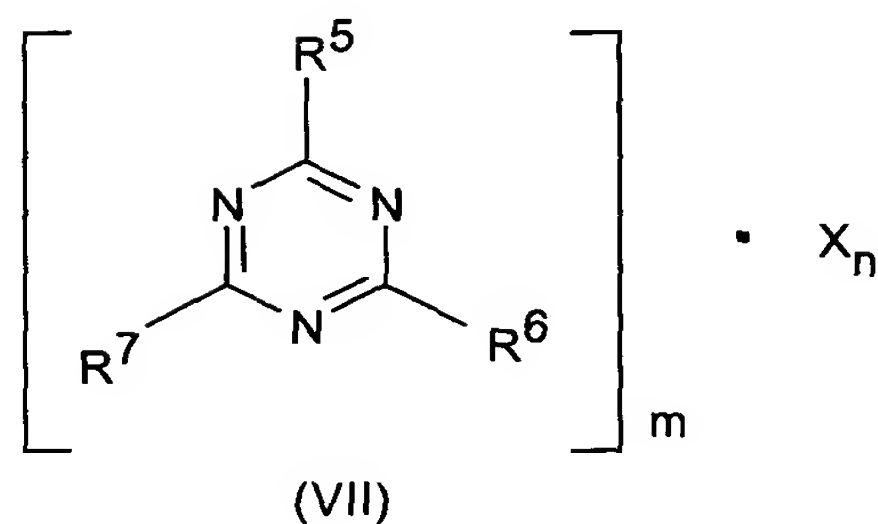
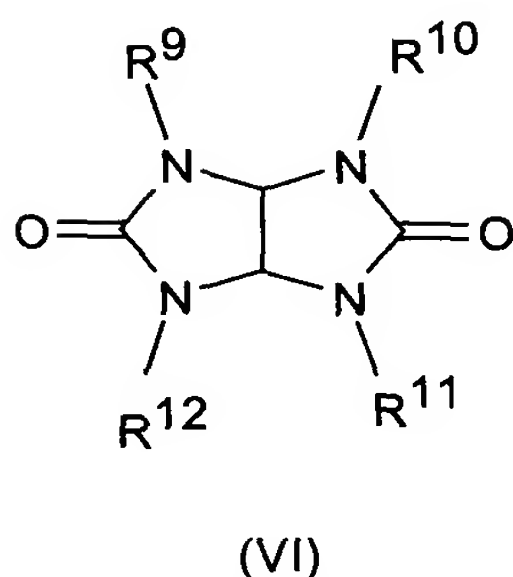
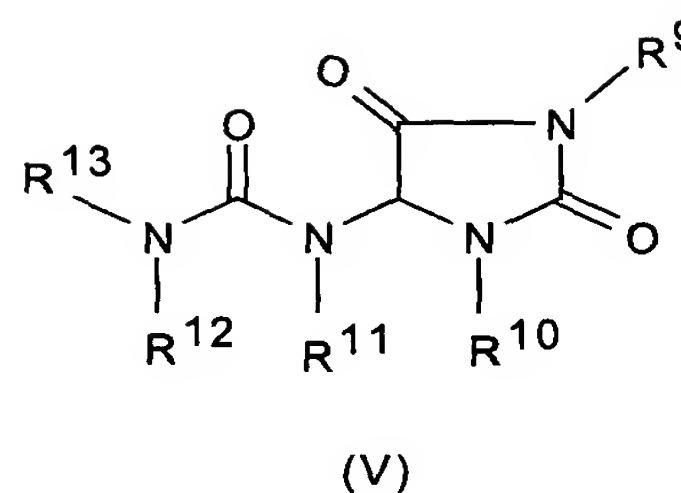
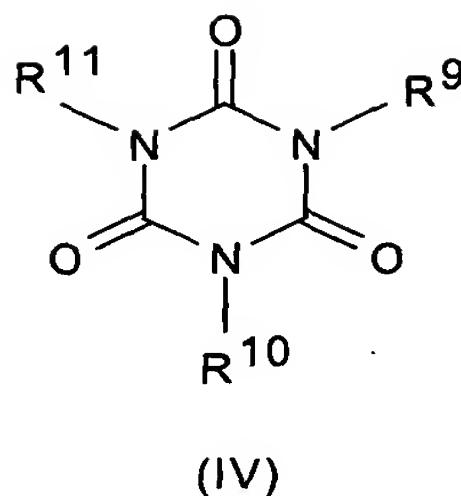
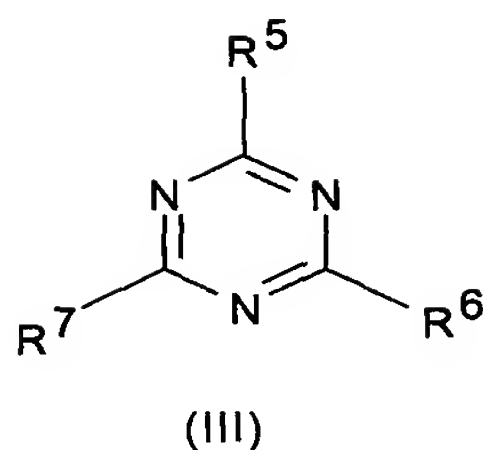
[00013] Protonated nitrogen bases are preferably the protonated bases of ammonia, melamine, or triethanolamine, in particular NH_4^+ .

- [00014] Preferred meanings of R^1 and R^2 , identical or different, are C_1 - C_6 -alkyl, linear or branched, and/or phenyl.
- [00015] Particularly preferred meanings of R^1 and R^2 , identical or different, are methyl, ethyl, n-propyl, isopropyl, n-butyl, tert-butyl, n-pentyl, and/or phenyl.
- [00016] Preferred meanings of R^3 are methylene, ethylene, n-propylene, isopropylene, n-butylene, tert-butylene, n-pentylene, n-octylene, or n-dodecylene.
- [00017] Other preferred meanings of R^3 are phenylene or naphthylene.
- [00018] Other preferred meanings of R^3 are methylphenylene, ethylphenylene, tert-butylphenylene, methylnaphthylene, ethylnaphthylene, or tert-butyl naphthylene.
- [00019] Other preferred meanings of R^3 are phenylmethylene, phenylethylene, phenylpropylene, or phenylbutylene.
- [00020] The granular flame-retardant composition and/or the organophosphorus flame-retardant component also preferably comprise(s) melamine phosphate, dimelamine phosphate, melamine pyrophosphate, melamine polyphosphates, melam polyphosphates, melem polyphosphates, and/or melon polyphosphates.
- [00021] The granular flame-retardant composition and/or the organophosphorus flame-retardant component also preferably comprise(s) melamine condensation products, such as melam, melem, and/or melon.

- [00022] Suitable substances are condensation products of melamine or reaction products of melamine with phosphoric acid, and reaction products of condensation products of melamine with phosphoric acid, and also mixtures of the products mentioned. Examples of condensation products of melamine are melem, melam, or melon, and compounds of this type but with a higher condensation level, and also mixtures of the same. One way of preparing these condensation products uses a process described in WO-A-96/16948.
- [00023] The reaction products with phosphoric acid are compounds resulting from reaction of melamine or of the condensed melamine compounds, such as melam, melem, or melon, etc., with phosphoric acid. Examples of these are melamine polyphosphate, melam polyphosphate, and melem polyphosphate, and mixed polysalts, e.g. as described in PCT/WO 98/39306. The compounds mentioned have been disclosed previously in the literature, and may also be prepared via processes other than the direct reaction with phosphoric acid. For example, melamine polyphosphate may be prepared by a method based on PCT/WO 98/45364, by reacting polyphosphoric acid and melamine, or by a method based on PCT/WO 98/08898 by condensation of melamine phosphate or melamine pyrophosphate.
- [00024] The granular flame-retardant composition and/or the organophosphorus flame-retardant component also preferably comprise(s) oligomeric esters of tris(hydroxyethyl) isocyanurate with aromatic polycarboxylic acids, benzoguanamine, tris(hydroxyethyl) isocyanurate, allantoin, glycoluril, melamine, melamine cyanurate, dicyandiamide, and/or guanidine.
- [00025] The granular flame-retardant composition and/or the organophosphorus flame-retardant component preferably comprise(s) nitrogen-containing

phosphates of the formulae $(\text{NH}_4)_y \text{H}_{3-y} \text{PO}_4$ and, respectively, $(\text{NH}_4 \text{PO}_3)_z$, where y is from 1 to 3 and z is from 1 to 10 000.

- [00026] The granular flame-retardant composition and/or the organophosphorus flame-retardant component preferably comprise(s), as component B, a synthetic inorganic compound and/or a mineral product.
- [00027] Component B is preferably an oxygen compound of silicon, or is magnesium compounds, is metal carbonates of metals of the second main group of the Periodic Table, is red phosphorus, is zinc compounds, or is aluminum compounds.
- [00028] The oxygen compounds of silicon are particularly preferably salts and esters of orthosilicic acid and condensation products thereof, or are silicates, zeolites, and silicas, are glass powder, glass/ceramic powder, or ceramic powder; the magnesium compounds are magnesium hydroxide, hydrotalcites, magnesium carbonates, or magnesium calcium carbonates; the zinc compounds are zinc oxide, zinc stannate, zinc hydroxystannate, zinc phosphate, zinc borate, or zinc sulfides; the aluminum compounds are aluminum hydroxide or aluminum phosphate.
- [00029] The granular flame-retardant composition and/or the organophosphorus flame-retardant component preferably comprise(s) nitrogen compounds as further component C.
- [00030] The nitrogen compounds are preferably those of the formulae (III) to (VIII) or mixtures thereof



where

R^5 to R^7 are hydrogen, C_1 - C_8 -alkyl, or C_5 - C_{16} -cycloalkyl or -alkylcycloalkyl, unsubstituted or substituted with a hydroxy function or with a C_1 - C_4 -hydroxyalkyl function, or are C_2 - C_8 -alkenyl, C_1 - C_8 -alkoxy, -acyl, or -acyloxy, are C_6 - C_{12} -aryl or -arylalkyl, are $-OR^8$ or are $-N(R^8)R^9$, or else N-alicyclic systems or N-aromatic systems,

R^8 is hydrogen, C_1 - C_8 -alkyl, C_5 - C_{16} -cycloalkyl or -alkylcycloalkyl, unsubstituted or substituted with a hydroxy function or with a C_1 -

C₄-hydroxyalkyl function, or is C₂-C₈-alkenyl, C₁-C₈-alkoxy, -acyl, or -acyloxy, or is C₆-C₁₂-aryl or -arylalkyl,
 R⁹ to R¹³ are the groups of R⁸, or else -O-R⁸,
 m and n, independently of one another, are 1, 2, 3, or 4,
 X is acids which can form adducts with triazine compounds (III).

[00031] The granular flame-retardant composition and/or the organophosphorus flame-retardant component preferably also comprise(s) carbodiimides.

[00032] The invention also includes synergistic combinations of the abovementioned phosphinates with certain nitrogen-containing compounds, these being more effective than the phosphinates alone as flame retardants in very many polymers (DE 196 14 424 A1, DE 197 34 437 A1, and DE-197 37 727 A1). The flame-retardant action of the phosphinates may be improved via combination with other flame retardants, preferably with nitrogen-containing synergists, or with phosphorus/nitrogen flame retardants.

[00033] Preferred binders are alkylalkoxylates, and among these preference is given to the use of ethoxylated alcohols, preferably primary alcohols, preferably having from 8 to 22 carbon atoms, and preferably from 1 to 80 EO units per mole of alcohol, the alcohol radical being linear or preferably methyl-branched at the 2-position, or comprising a mixture of linear and methyl-branched radicals, as is usually the case in oxo alcohol radicals. Examples of preferred ethoxylated alcohols are C₁₁ alcohols having 3, 5, 7, 8 or 11 EO units, (C₁₂-C₁₅) alcohols having 3, 6, 7, 8, 10 or 13 EO units, (C₁₄-C₁₅) alcohols having 4, 7 or 8 EO units, (C₁₆-C₁₈) alcohols having 8, 11, 15, 20, 25, 50 or 80 EO units, and mixtures of the same, e.g. the ®Genapol grades T80, T110, T150, T200, T250, T500, T800 from Clariant GmbH. The degrees of ethoxylation given are statistical averages which for a specific product

may be an integer or a non-integer. In addition to these, use may also be made of fatty alcohol-EO/PO adducts.

[00034] Other preferred binders are caprolactam and triphenyl phosphate.

[00035] The binder preferably comprises ethylene glycol, propylene glycol and/or butylene glycol, their oligomers and/or polymers and/or their ethers.

[00036] The binder preferably comprises naturally occurring, chemically modified and/or synthetic waxes, preferably carnauba waxes and montan waxes.

[00037] Waxes are naturally occurring or synthesized substances which at 20°C are solid and kneadable, and above 40°C undergo melting without decomposition and have low viscosity. The temperature at which waxes generally convert into the molten, low-viscosity state is from 50 to 90°C, or in exceptional cases up to about 200°C. A distinction is made between naturally occurring waxes, such as carnauba wax, chemically modified waxes, such as montan ester waxes, and synthetic waxes, such as polyethylene waxes.

[00038] Montan waxes for polymer processing are internal and external lubricants for the processing of polyvinyl chloride, polyolefins, polyamide, polystyrene, linear polyesters, thermoplastic polyurethane, curable molding compositions, and other polymers. They are downstream products from the refining of crude montan wax, which is obtained by extracting brown coal. They are long-chain carboxylic acids having chain lengths of from C28 to C32, or are their full or partial esters with ethylene glycol, glycerol, or butylene glycol, or are alkaline earth metal salts of partially hydrolyzed esters, e.g. ®Licowax E, ®Licowax WE 4, and ®Licowax OP.

- [00039] Polyethylene waxes are suitable for the polymer sector (PVC, rubber, polyolefins). Examples are [®]Licowax PE 520, [®]Licowax PE 810, [®]Licowax PE 820, [®]Licowax PE 830, [®]Licowax PE 840, [®]Licomont CaV, [®]Licolub WE4, Ceridust 5551.
- [00040] The binder preferably comprises synthetic resins, particularly phenolic resins. According to DIN 55958, synthetic resins are synthetic resins prepared by a polymerization reaction, polyaddition reaction, or polycondensation reaction. An example of a preferred phenolic resin is the grade 28391 from the company Durez.
- [00041] Other suitable binders are polyethylene glycols $H(OCH_2CH_2O)_nOH$ with molecular weights of from 500 to 40 000. Particular preference is given to the grades [®]PEG 600, 800, 1000, 1500, 2000, 3000, 4000, 6000, 8000, 10 000, 12 000, 20 000, 35 000 from the company Clariant GmbH.
- [00042] Other suitable binders are monoalkyl ethers of polyethylene glycol, monoallyl ethers of polyethylene glycol, and monovinyl ethers of polyethylene glycol.
- [00043] Preferred binders are esters, amides, anhydrides, hydrates, and salts of saturated aliphatic mono-, di-, tri- and polycarboxylic acids.
- [00044] Other preferred binders are C_1-C_{20} -(alkyl, oxalkyl, alkenyl, alkynyl, aralkyl, alkylaryl, or aryl) monocarboxylates, C_1-C_{20} -(alkyl, oxalkyl, alkenyl, alkynyl, aralkyl, alkylaryl, or aryl) dicarboxylates, C_1-C_{20} -(alkyl, oxalkyl, alkenyl, alkynyl, aralkyl, alkylaryl, or aryl) tricarboxylates, C_1-C_{20} -(alkyl, oxalkyl, alkenyl, alkynyl, aralkyl, alkylaryl, or aryl)

oligocarboxylates, C₁-C₂₀-(alkyl, oxalkyl, alkenyl, alkynyl, aralkyl, alkylaryl or aryl) polycarboxylates.

- [00045] Other preferred binders are monoorganyl or diorganyl esters of a dicarboxylic acid; monoorganyl or diorganyl, or triorganyl esters of a tricarboxylic acid; monoorganyl, diorganyl, triorganyl, or oligoorganyl esters of an oligocarboxylic acid; monoorganyl, diorganyl, triorganyl, oligoorganyl, or polyorganyl esters of a polycarboxylic acid, or a mixture of these.
- [00046] Other preferred binders are esters of phthalic acid, among which are monoorganyl esters of phthalic acid and bisorganyl esters of phthalic acid (examples of organyl being alkyl, oxalkyl, alkenyl, alkynyl, aralkyl, alkylaryl or aryl), preference being given to monoalkyl esters of phthalic acid and dialkyl esters of phthalic acid (alkyl = linear, branched, cyclic, substituted cyclic, or heterocyclic C₁-C₂₀), e.g. dimethyl phthalate, diethyl phthalate, dipropyl phthalate, diisopropyl phthalate, dibutyl phthalate, epoxidized di(2-ethylhexyl) phthalate, diisooctyl phthalate, dioctyl phthalate, diisononyl phthalate, n-octyl phthalate, n-decyl phthalate, diisodecyl phthalate, butyl benzyl phthalate, butyl cyclohexyl phthalate, dicapryl phthalate, di(3,5,5-trimethylhexyl) phthalate, di(1-allyl-2,2,6,6-tetramethylpiperidin-4-yl) phthalate.
- [00047] Other preferred binders are esters of isophthalic acid, among which are monoorganyl esters of isophthalic acid and bisorganyl esters of isophthalic acid (examples of organyl being alkyl, oxalkyl, alkenyl, alkynyl, aralkyl, alkylaryl, or aryl), preference being given to monoalkyl esters of isophthalic acid and dialkyl esters of isophthalic acid (alkyl = linear, branched, cyclic, substituted cyclic, or heterocyclic C₁-C₂₀), e.g. di(2-ethylhexyl) isophthalate.

- [00048] Other preferred binders are esters of terephthalic acid, among which are monoorganyl esters of terephthalic acid and bisorganyl esters of terephthalic acid (examples of organyl being alkyl, oxalkyl, alkenyl, alkynyl, aralkyl, alkylaryl, or aryl), preference being given to monoalkyl esters of terephthalic acid and dialkyl esters of terephthalic acid (alkyl = linear, branched, cyclic, substituted cyclic, or heterocyclic C₁-C₂₀).
- [00049] Other preferred binders are esters of oxalic acid, esters of malonic acid (e.g. di(2,2,6,6-tetramethylpiperidin-4-yl) diethylmalonate, di(1,2,2,6,6-pentamethylpiperidin-4-yl) dibutylmalonate, di(1,2,2,6,6-pentamethylpiperidin-4-yl) butyl(3,5-di-tert-butyl-4-hydroxybenzyl)malonate), esters of succinic acid (e.g. di(2,2,6,6-tetramethylpiperidin-4-yl) succinate), and esters of glutaric acid (e.g. di(2,2,6,6-tetramethylpiperidin-4-yl) glutarate).
- [00050] Other preferred binders are esters of adipic acid, among which are monoorganyl esters of adipic acid and bisorganyl esters of adipic acid (examples of organyl being alkyl, oxalkyl, alkenyl, alkynyl, aralkyl, alkylaryl, or aryl), preference being given to monoalkyl esters of adipic acid and dialkyl esters of adipic acid (alkyl = linear, branched, cyclic, substituted cyclic, or heterocyclic C₁-C₂₀), e.g. dimethyl adipate, diethyl adipate, di-n-propyl adipate, diisopropyl adipate, di-n-butyl adipate, diisobutyl adipate, di-tert-butyl adipate, di(n-octyl) adipate, di(2-ethylhexyl) adipate, diisodecyl adipate, n-octyl adipate, 2-ethylhexyl adipate, n-decyl adipate, isodecyl adipate, di(2,2,6,6-tetramethylpiperidin-4-yl) adipate.
- [00051] Other preferred binders are esters of pimelic acid, suberic acid, esters of azelaic acid (e.g. dialkyl azelate, particularly di(2-ethylhexyl) azelate), and esters of 1,13-tridecanedicarboxylic acid (brassylic acid).

- [00052] Other preferred binders are esters of sebacic acid, among which are monoorganyl esters of sebacic acid and diorganyl esters of sebacic acid (examples of organyl being alkyl, oxalkyl, alkenyl, alkynyl, aralkyl, alkylaryl, or aryl), preference being given to monoalkyl esters of sebacic acid and dialkyl esters of sebacic acid (alkyl = linear, branched, cyclic, substituted cyclic, or heterocyclic C₁-C₂₀), e.g. dialkyl sebacate, particularly di(2-ethylhexyl) sebacate, di(2,2,6,6-tetramethylpiperidin-4-yl) sebacate, di(1,2,2,6,6-pentamethylpiperidin-4-yl) sebacate, di(1,2,3,6-tetramethyl-2,6-diethyl-piperidin-4-yl) sebacate, di(1-octyloxy-2,2,6,6-tetramethylpiperidin-4-yl) sebacate, di(1-cyclohexyloxy-2,2,6,6-tetramethylpiperidin-4-yl) sebacate.
- [00053] Other preferred binders are esters of tetrahydrophthalic acid, among which are monoorganyl esters of tetrahydrophthalic acid and bisorganyl esters of tetrahydrophthalic acid (examples of organyl being alkyl, oxalkyl, alkenyl, alkynyl, aralkyl, alkylaryl, or aryl), preference being given to monoalkyl esters of tetrahydrophthalic acid and dialkyl esters of tetrahydrophthalic acid (alkyl = linear, branched, cyclic, substituted cyclic, or heterocyclic C₁-C₂₀), e.g. di(2-ethylhexyl) tetrahydrophthalate.
- [00054] Other preferred binders are esters of tetrahydroisophthalic acid, among which are monoorganyl esters of tetrahydrophthalic acid and bisorganyl esters of tetrahydroisophthalic acid (examples of organyl being alkyl, oxalkyl, alkenyl, alkynyl, aralkyl, alkylaryl, or aryl), preference being given to monoalkyl esters of tetrahydroisophthalic acid and dialkyl esters of tetrahydroisophthalic acid (alkyl = linear, branched, cyclic, substituted cyclic, or heterocyclic C₁-C₂₀).
- [00055] Other preferred binders are esters of tetrahydroterephthalic acid, among which are monoorganyl esters of tetrahydroterephthalic acid and bisorganyl esters of tetrahydroterephthalic acid (examples of organyl

being alkyl, oxalkyl, alkenyl, alkynyl, aralkyl, alkylaryl, or aryl), preference being given to monoalkyl esters of tetrahydroterephthalic acid and dialkyl esters of tetrahydroterephthalic acid (alkyl = linear, branched, cyclic, substituted cyclic, or heterocyclic C₁-C₂₀).

- [00056] Other preferred binders are esters of hexahydrophthalic acid, among which are monoorganyl esters of hexahydrophthalic acid and bisorganyl esters of aralkyl, hexahydrophthalic acid (examples of organyl being alkyl, oxalkyl, alkenyl, alkynyl, aralkyl, alkylaryl, or aryl), preference being given to monoalkyl esters of hexahydrophthalic acid and dialkyl esters of hexahydrophthalic acid (alkyl = linear, branched, cyclic, substituted cyclic, or heterocyclic C₁-C₂₀), e.g. di(2-ethylhexyl) hexahydrophthalate.
- [00057] Other preferred binders are esters of hexahydroisophthalic acid, among which are monoorganyl esters of hexahydroisophthalic acid and bisorganyl esters of aralkyl, hexahydroisophthalic acid (examples of organyl being alkyl, oxalkyl, alkenyl, alkynyl, alkylaryl, or aryl), preference being given to monoalkyl esters of hexahydroisophthalic acid and dialkyl esters of hexahydroisophthalic acid (alkyl = linear, branched, cyclic, substituted cyclic, or heterocyclic C₁-C₂₀).
- [00058] Other preferred binders are esters of hexahydroterephthalic acid, among which are monoorganyl esters of hexahydroterephthalic acid and bisorganyl esters of hexahydroterephthalic acid (examples of organyl being alkyl, oxalkyl, alkenyl, alkynyl, aralkyl, alkylaryl, or aryl), preference being given to monoalkyl esters of hexahydroterephthalic acid and dialkyl esters of hexahydroterephthalic acid (alkyl = linear, branched, cyclic, substituted cyclic, or heterocyclic C₁-C₂₀).

- [00059] Other preferred binders are esters of maleic acid, among which are monoorganyl esters of maleic acid and bisorganyl esters of maleic acid (examples of organyl being alkyl, oxalkyl, alkenyl, alkynyl, aralkyl, alkylaryl, or aryl), preference being given to monoalkyl esters of maleic acid and dialkyl esters of maleic acid (alkyl = linear, branched, cyclic, substituted cyclic, or heterocyclic C₁-C₂₀), e.g. di(1-benzyl-2,2,6,6-tetramethylpiperidin-4-yl) maleate.
- [00060] Other preferred binders are esters of hydroxycarboxylic acids, hydroxydicarboxylic acids, hydroxytricarboxylic acids, hydroxyoligocarboxylic acids, and/or hydroxypolycarboxylic acids, e.g. tartronic acid, malic acid, tartaric acid, citric acid, etc.
- [00061] Other preferred binders are esters of citric acid, among which are monoorganyl esters of citric acid and bisorganyl esters of citric acid (examples of organyl being alkyl, oxalkyl, alkenyl, alkynyl, aralkyl, alkylaryl, or aryl), preference being given to monoalkyl esters of citric acid and dialkyl esters of citric acid (alkyl = linear, branched, cyclic, substituted cyclic, or heterocyclic C₁-C₂₀).
- [00062] Other preferred binders are butyl epoxystearate, hexyl epoxystearate, epoxidized soy oil, epoxidized octyl tallate, epoxidized octyl oleate, tetraethylene glycol di(2-ethylhexoate), and triethyleneglycol di(2-ethylhexoate).
- [00063] Other preferred binders are esters of mono-, di-, tri-, tetra-, or pentahydric alcohols, and those of higher polyols.
- [00064] Other preferred binders are mono-, di-, tri-, or tetraorganyl esters of pentaerythritol, and mixtures of these, e.g. pentaerythritol tetrabenzoate.

- [00065] Other preferred binders are sulfonamide-based compounds, particularly preferably aromatic sulfonamides, e.g. N-ethyltoluenesulfonamide, N-cyclohexyltoluenesulfonamide, N-butylbenzenesulfonamide, N-methylbenzenesulfonamide, N-butylbenzenesulfonamide, p-toluenesulfonamide, N-ethyl-p-toluenesulfonamide, and N-cyclohexyl-p-toluenesulfonamide.
- [00066] Other preferred binders are glycerol, hexyl glycol, and modified urethane prepolymer which has a weight-average molecular weight of from 400 to 2 000, preferably from 600 to 1 000.
- [00067] Other preferred binders are esters of p-hydroxybenzoic acid, e.g. hexyloxyethoxyethyl p-hydroxybenzoate, hexyloxypropoxypropyl p-hydroxybenzoate, hexyloxybutoxybutyl p-hydroxybenzoate, octyloxyethoxyethyl p-hydroxybenzoate, octyloxypropoxypropyl p-hydroxybenzoate, octyloxybutoxybutyl p-hydroxybenzoate, 2'-ethylhexyloxyethoxyethyl p-hydroxybenzoate, 2'-ethylhexyloxypropoxypropyl p-hydroxybenzoate, 2'-ethylhexyloxybutoxybutyl p-hydroxybenzoate, decyloxyethoxyethyl p-hydroxybenzoate, decyloxypropoxypropyl p-hydroxybenzoate, decyloxybutoxybutyl p-hydroxybenzoate.
- [00068] Other preferred binders are alkyl esters of p-hydroxybenzoic acid, e.g. octyl p-hydroxybenzoate, 2-ethylhexyl p-hydroxybenzoate, heptyl p-hydroxybenzoate, 2-ethyldecyl p-hydroxybenzoate, 2-octyloctyl p-hydroxybenzoate, and 2-decyldodecyl p-hydroxybenzoate.
- [00069] Other preferred binders are phenols, such as beta-naphthol, dibenzylphenol, and octylcresol.

- [00070] Phosphorus compounds of oxidation state +5 which may be used are especially alkyl- and aryl-substituted phosphates. Examples are phenyl bisdodecyl phosphate, phenyl ethyl hydrogenphosphate, phenyl bis(3,5,5-trimethylhexyl) phosphate, ethyl diphenyl phosphate, 2-ethylhexyl di(tolyl) phosphate, diphenyl hydrogenphosphate, bis(2-ethylhexyl) p-tolyl phosphate, tritolyl phosphate, bis(2-ethylhexyl) phenyl phosphate, di(nonyl) phenyl phosphate, phenyl methyl hydrogenphosphate, di(dodecyl) p-tolyl phosphate, p-tolyl bis(2,5,5-trimethylhexyl) phosphate, or 2-ethylhexyl diphenyl phosphate. Triphenyl phosphate, and resorcinol bis(diphenyl phosphate) (RDP) and its ring-substituted derivatives are very particularly suitable.
- [00071] Other preferred binders are tri(butoxyethyl) phosphate, trioctyl phosphate, tricresyl phosphate, 2-ethylhexyl diphenyl phosphate, cresyl diphenyl phosphate.
- [00072] Other preferred binders are organic salts of polyvalent metals, particularly preferably organic salts of elements of the second, third, or fourth main group, or of the second transition group, particularly of the elements magnesium, calcium, strontium, barium, zinc, cadmium, aluminum, tin, lead. Particular preference is given to carboxylic acids having at least 12 carbon atoms, dodecanoic acid (lauric acid), coconut acid, tetradecanoic acid (myristic acid), hexadecanoic acid (palmitic acid, cetylic acid), octadecanoic acid (stearic acid), cis-9-octadecenoic acid (oleic acid), trans-9-octadecenoic acid (elaidic acid), eicosanoic acid (arachidic acid), docosanoic acid (behenic acid).
- [00073] The median particle size of the organophosphorus flame-retardant component is from 0.1 to 1 000 μm , preferably from 1 to 100 μm .

- [00074] The median particle size of the granular flame-retardant composition is from 100 to 10 000 μm , preferably from 200 to 2 000 μm .
- [00075] The preferred bulk density of the organophosphorus flame-retardant component is from 80 to 800 g/l, particularly preferably from 200 to 800 g/l.
- [00076] The preferred bulk density of the granular flame-retardant composition is from 200 to 1 500 g/l, particularly preferably from 300 to 700 g/l.
- [00077] The preferred ratio of the amount of binder to that of organophosphorus component is from 1:99 to 1:0.11, preferably from 1:49 to 1:0.25, particularly preferably from 1:19 to 1:1.
- [00078] The melting/drop point of the binder is preferably from 50 to 200°C.
- [00079] The preferred process for preparing the granular flame-retardant composition of the invention is melt agglomeration. In this process, a binder is partially melted via exposure to external heat and via heat generated by shear forces. This acts in combination with the shear forces introduced to enlarge the solid particles. In the agglomerates which form, the solid particles are held together via binder bridges which form.
- [00080] In one embodiment, the inventive granular flame-retardant composition may be prepared by adding, in a suitable mixer, the binder in liquid form to the organophosphorus flame-retardant component, which has been set in motion, and mixing for from 0.01 to 1 hour at from 50 to 300°C.
- [00081] In one embodiment, the inventive granular flame-retardant composition may be prepared by adding, in a suitable mixer, the solid binder to the

organophosphorus flame-retardant component, which has been set in motion, mixing for from 0.01 to 1 hour at 50 to 300°C, and, previously/simultaneously/subsequently heating to the melting point of the binder.

- [00082] Suitable mixers may be: plowshare mixers from the company Lödige, rotating-disc mixers from the company Lödige, (e.g. CB30), Flexomix mixers from the company Schugi, HEC rotating-disc mixers from the company Niro, rotating-disc mixers (e.g. K-TTE4) from the company Drais, Mannheim, Germany, Eirich mixers (e.g. R02), Telschig mixers (WPA6), Hauf mixers, (the last two mixers using the free-fall principle of operation), zig-zag mixers from the company Niro, and mixers from the company Nauta, in which the mix is circulated by a screw, using the Archimedes principle.
- [00083] The product mixture initially produced is dried in a suitable dryer, and, respectively, annealed to continue build-up of the grains. Dryers of the invention may be: fluidized-bed dryers from the company Hosokawa Schugi (Schugi Fluid-Bed, Vometec fluidized-bed dryers), fluidized-bed dryers from the company Waldner or from the company Glatt, turbo-fluidized-bed dryers from the company Waldner, spin-flash dryers from the company Anhydro, or else drum dryers.
- [00084] Preferred operating conditions in the fluidized-bed dryer are: air inlet temperature from 120 to 280°C, product temperature from 20 to 200°C.
- [00085] In one embodiment, the inventive granular flame-retardant composition may be prepared by melting the organophosphorus flame-retardant component with a binder, and freezing the material in the form of drops. The melting process may take place in a kneader, in a stirred tank, or in

similar assemblies. It is preferable to freeze the melt in a fluidized bed, pelletizing pan, or on a metal belt.

- [00086] The residual moisture level of the inventive granular flame-retardant composition is from 0.01 to 10%, preferably from 0.05 to 1%.
- [00087] The invention also provides a flame-retardant polymer molding composition which comprises the inventive granular flame-retardant composition.
- [00088] The flame-retardant polymer molding composition preferably comprises
from 1 to 50% by weight of granular flame-retardant composition,
from 1 to 99% by weight of thermoplastic polymer or a mixture of the same
from 0 to 60% by weight of additives
from 0 to 60% by weight of filler.
- [00089] The flame-retardant polymer molding composition particularly preferably comprises
from 5 to 30% by weight of granular flame-retardant composition,
from 5 to 90% by weight of thermoplastic polymer or a mixture of the same
from 5 to 40% by weight of additives
from 5 to 40% by weight of filler.
- [00090] The flame-retardant polymer molding composition preferably also comprises component B and/or C, as described above.
- [00091] The thermoplastic polymers are preferably HI (high-impact) polystyrene, polyphenylene ethers, polyamides, polyesters, polycarbonates, or blends or polyblends of the type represented by ABS (acrylonitrile-

butadiene-styrene), or PC/ABS (polycarbonate/acrylonitrile-butadiene-styrene).

- [00092] The thermoplastic polymers are particularly preferably polyamide, polyester, or ABS.
- [00093] Finally, the invention also provides polymer moldings, polymer films, polymer filaments, or polymer fibers, comprising the granular flame-retardant composition of the invention.
- [00094] The polymer of the polymer moldings, polymer films, polymer filaments, or polymer fibers is a thermoplastic or thermoset polymer.
- [00095] The thermoplastic polymers are preferably HI (high-impact) polystyrene, polyphenylene ethers, polyamides, polyesters, polycarbonates, or blends or polyblends of the type represented by ABS (acrylonitrile-butadiene-styrene), or PC/ABS (polycarbonate/acrylonitrile-butadiene-styrene), polyamide, polyester, and/or ABS.
- [00096] Preferred thermoplastic polymers are polyethylene (PE), polypropylene (PP), polystyrene (PS), polyvinyl chloride (PVC), polyacrylonitrile (PAN), and polyacrylates.
- [00097] The thermoset polymers are preferably formaldehyde polymers, epoxy polymers, melamine polymers, or phenolic resin polymers, and/or polyurethanes.
- [00098] The polymer moldings, polymer films, polymer filaments, or polymer fibers preferably comprise
from 1 to 50% by weight of granular flame-retardant composition,
from 1 to 99% by weight of polymer or a mixture of the same

from 0 to 60% by weight of additives

from 0 to 60% by weight of filler.

- [00099] The polymer moldings, polymer films, polymer filaments, or polymer fibers particularly preferably comprise
from 5 to 30% by weight of granular flame-retardant composition,
from 5 to 90% by weight of polymer or a mixture of the same
from 5 to 40% by weight of additives
from 5 to 40% by weight of filler.
- [000100] The inventive granular flame-retardant composition is preferably used in compounded materials which are in turn used to produce polymer moldings.
- [000101] The invention also includes polymer moldings which comprise the inventive granular flame-retardant composition.
- [000102] The flame-retardant components may be incorporated into thermoplastic polymers, for example by premixing all of the constituents in the form of powders and/or granulated materials in a mixer, and then homogenizing in the polymer melt in a compounding assembly (e.g. a twin-screw extruder). The melt is usually drawn off in the form of a strand, cooled, and pelletized. The components may also be introduced separately by way of a feed system directly into the compounding assembly.
- [000103] It is also possible to admix the flame-retardant additions with ready-to-use polymer pellets and, respectively, ready-to-use polymer powder, and to process the mixture directly in an injection-molding machine to give moldings.

- [000104] Preferred fillers are glass (preferably in bead form or in fiber form), oxides and/or hydroxides of the elements of the second or third main group of the Periodic Table of the Elements (preferably aluminum and magnesium), phyllosilicates, and clay minerals, e.g. bentonites, montmorillonites, hectorites, saponites, precipitated/fumed/crystalline/amorphous silicas, chalk.
- [000105] Preferred additives are synergists, antioxidants, light stabilizers, lubricants, colorants, nucleating agents, or antistatic agents. Examples of additives which can be used are given in EP 0 584 567 A1.
- [000106] The invention also provides an intumescent flame-retardant coating comprising at least
from 1 to 50% of granular flame-retardant composition
from 0 to 60% of ammonium polyphosphate.

Experimental section

- [000107] Determination of particle size distribution in the granular flame-retardant composition of the invention by sieve analysis:
- [000108] The inserts with appropriate sieves are used in a Retsch sieving machine. The mesh width of the sieves here decreases from the top to the bottom. 50 g of the powder to be tested are applied to the widest sieve. The vibratory movement of the sieving machine causes the pulverulent material to move through the various sieves. The residues on the sieves are weighed, and a calculation is made to relate these to the weight of material used. From the values it is possible to calculate the d_{50} value.

- [000109] Determination of particle size distribution using the Microtrac Granulometer
- [000110] Particle size in aqueous dispersion is determined with the aid of a Microtrac ASVR/FRA Granulometer from the company Leeds and Northrup. The degree of reflection or scattering of a laser beam is measured as it penetrates the dispersion. For this, 400 ml of ethanol are pumped through the laser measurement cell. The solid specimen (e.g. 70 mg) is metered in automatically, and after 10 min the particle size distribution is determined. The evaluation unit of the equipment calculates the d_{50} value and the d_{90} value.
- [000111] Preparation, processing, and testing of flame-retardant compounded materials and polymer moldings
- [000112] The flame-retardant components are mixed with the polymer granules and, where appropriate, with additives, and incorporated in a twin-screw extruder (Leistritz LSM 30/34) at temperatures of from 230 to 260°C (GR PBT) and, respectively, from 260 to 280°C (GR PA 66). The homogenized polymer strand is drawn off, cooled in the waterbath, and then granulated.
- [000113] After adequate drying, the molding compositions are processed on an injection molding machine (Aarburg Allrounder) at melt temperatures of from 240 to 270°C (GR PBT) and, respectively, from 260 to 290°C (GR PA 66) to give test specimens, and tested and classified for flame retardancy, using the UL 94 test (Underwriters Laboratories).
- [000114] Example 1 (inventive)
1 276 g of aluminum diethylphosphinate (median particle diameter $d_{50} = 3 \mu\text{m}$) are mixed with 224 g of [®]Licowax E in an Eirich laboratory mixer,

and heated. Mixing is continued until the granulation process begins. The raw material is cooled and sieved. This gives 58.4% by weight of correct-size melt granules (from 400 to 1 400 μm).

Example 2 (inventive)

[000115] 1 394 g of aluminum diethylphosphinate are mixed with 106 g of [®]Licowax E in an Eirich laboratory mixer, and heated. Mixing is continued until the granulation process begins. The raw material is cooled and sieved. This gives 36.7% by weight of correct-size melt granules (from 400 to 1 400 μm).

Example 3 (inventive)

[000116] 1 470 g of aluminum diethylphosphinate are mixed with 30 g of [®]Licowax E in an Eirich laboratory mixer, and heated. Mixing is continued until the granulation process begins. The raw material is cooled and sieved. This gives 13% by weight of correct-size melt granules (from 400 to 1 400 μm).

Example 4 (inventive)

[000117] 1 395 g of aluminum diethylphosphinate (median particle diameter $d_{50} = 56 \mu\text{m}$) are mixed with 105 g of [®]Licowax PE 520 in an Eirich laboratory mixer, and heated. Mixing is continued until the granulation process begins. The raw material is cooled and sieved. This gives 36.6% by weight of correct-size melt granules (from 400 to 1 400 μm).

Example 5 (inventive)

[000118] 1 395 g of aluminum diethylphosphinate are mixed with 105 g of [®]Licolub WE4FI in an Eirich laboratory mixer, and heated. Mixing is continued until the granulation process begins. The raw material is cooled and sieved. This gives 38.8% by weight of correct-size melt granules (from 400 to 1 400 μm).

Example 6 (inventive)

[000119] 1 425 g of aluminum diethylphosphinate are mixed with 75 g of [®]Genapol T500 in an Eirich laboratory mixer, and heated. Mixing is continued until the granulation process begins. The raw material is cooled and sieved. This gives 23% by weight of correct-size melt granules (from 400 to 1 400 μm).

Example 7 (inventive)

[000120] 1 425 g of aluminum diethylphosphinate are mixed with 75 g of [®]PEG 6000 in an Eirich laboratory mixer, and heated. Mixing is continued until the granulation process begins. The raw material is cooled and sieved. This gives 32.1% by weight of correct-size melt granules (from 400 to 1 400 μm).

Example 8 (inventive)

[000121] 1 500 g of Melapur[®] MP melamine polyphosphate (melamine phosphate) from the company DSM Melapur, NL are mixed with 1 500 g of aluminum diethylphosphinate for 5 min in a Hobart mixer.

Example 9 (inventive)

[000122] 1 425 g of organophosphorus flame-retardant component from example 8 are mixed with 75 g of [®]Licowax E in an Eirich laboratory mixer, and heated. Mixing is continued until the granulation process begins. The raw material is cooled and sieved. This gives 29.8% by weight of correct-size melt granules (from 400 to 1 400 μm).

Example 10 (inventive)

[000123] 750 g of aluminum diethylphosphinate are mixed with 750 g of Durez resin grade 28391 in a laboratory kneader, and melted. The melt is

transferred dropwise to a metal belt, and freezes. This gives flat, drop-shaped pellets with a diameter of about 6 mm.

Example 11 (comparison)

- [000124] In accordance with the general specification, a mixture of 57.5% by weight of nylon-6,6 ([®]Ultramid A3), 30% by weight of glass fibers ([®]Vetrotex EC 10 4.5 mm 98 A), and 12.5% by weight of aluminum diethylphosphinate is cast to give test specimens. Visual sampling reveals white inhomogeneities on the test specimen surface. Performance in the UL 94 fire test is inadequate for V-1 classification.

Example 12 (inventive)

- [000125] In accordance with the general specification, a mixture of 57.5% by weight of nylon-6,6 ([®]Ultramid A3), 30% by weight of glass fibers ([®]Vetrotex EC 10 4.5 mm 98 A), and 12.5% by weight of granular flame-retardant composition from example 1 is cast to give test specimens. Visual sampling reveals that the test specimen surface is free from inhomogeneities. In the UL 94 fire test, V-0 classification is achieved.

Example 13 (inventive)

- [000126] In accordance with the general specification, a mixture of 57.5% by weight of nylon-6,6 ([®]Ultramid A3), 30% by weight of glass fibers ([®]Vetrotex EC 10 4.5 mm 98 A), and 12.5% by weight of granular flame-retardant composition from example 4 is cast to give test specimens. Visual sampling reveals that the test specimen surface is free from inhomogeneities. In the UL 94 fire test, V-0 classification is achieved.

Example 14 (inventive)

- [000127] 20 parts of the flame-retardant from example 1 are mixed with 50 parts of polybutylene terephthalate pellets and 30 parts of glass fibers, and incorporated in a twin-screw extruder (Leistritz LSM 30/34) at

temperatures of from 230 to 260°C (GR PBT). The homogenized polymer strand is drawn off, cooled in a water bath, and then pelletized. After adequate drying, the pellets are processed on an injection molding machine (Aarburg Allrounder) at melt temperatures of from 240 to 270°C (GR PBT) to give moldings. In the UL 94 fire test, the V-0 classification is achieved.

Table 1: Properties of granular flame-retardant compositions

Example	*OPF Weight used g	Binder			Product			
		Type	Weight used g	Weight used %	Undersize particles < 400µ %	Correct-size particles %	Oversize particles > 1400µ %	Bulk density g/l
Starting material Ex 1	-	-	-	-	-	-	-	160
1	1 276	Licowax E	224	15	9.7	58.4	31.9	857
2	1 394	Licowax E	106	7	21.2	36.7	42.1	488
3	1 470	Licowax E	30	2	82.5	13	4.5	305
4	1 395	Licowax PE 520	105	7	56.3	36.6	7.1	661
5	1 395	Licolub WE4FI	105	7	27.9	38.8	33.3	646
6	1 425	Genapol T500	75	5	27	23	50	589
7	1 425	PEG 6000	75	5	25.6	32.1	42.3	570
9	1 425	Licowax E	75	5	37.8	29.8	32.4	617
10	750	Durez resin grade 28391	750	50	-	-	-	753

*OPF: organophosphorus flame-retardant component

Table 2: Compositions of moldings and test results

Example	Composition of molding				Tests on moldings		Comments
	*OPF	**GFR	Glass fiber	Nylon-6,6	Visual	UL 94 fire test	
	% by weight	% by weight	% by weight	% by weight	-	-	-
11	12.5	-	30	57.5	inhomogeneous	V-1	OPF: from Ex. 1
12	-	12.5	30	57.5	homogeneous	V-0	GFR: from Ex. 1
13	-	12.5	30	57.5	homogeneous	V-0	GFR: from Ex. 9
14		20	30	50	homogeneous	V-0	GFR: from Ex. 1

*OPF: organophosphorus flame-retardant component

**GFR: granular flame-retardant composition